MOP047

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# Progress of IFMIF/EVEDA Project and Prospects for A-FNS

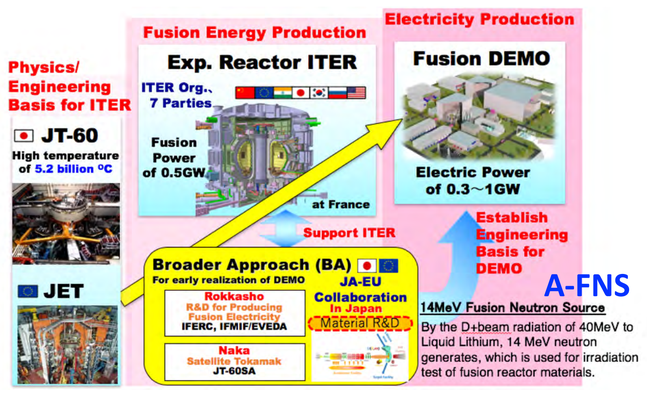
S. Ishida†, A. Kasugai, K. Sakamoto(QST, Rokkasho, Japan) , P. Cara (IFMIF/EVEDA Project Team, Rokkasho, Japan) , H. Dzitko (Fusion for Energy, Garching, Germany)

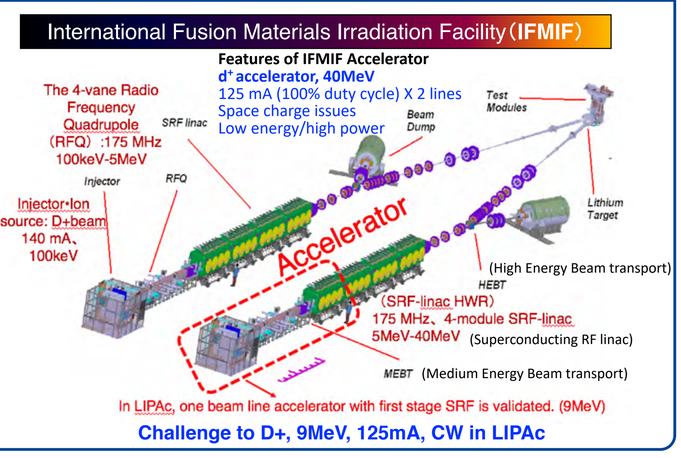
International Fusion Materials Irradiation Facility (IFMIF) is an accelerator-based D-Li neutron source, in which two 40 MeV Deuteron(D) beams with a total current 250 mA impact on a liquid Li stream flowing at 15 m/s. In the IFMIF/EVEDA project under the Broader Approach (BA) agreement, the Li target was continuously operated with the cold trap and satisfied the stability requirement throughout the continuous operation. The Linear IFMIF Prototype Accelerator (LIPAc) is currently under development in Rokkasho, Japan, to demonstrate the 9 MeV/125 mA D+ beam acceleration. Recently, the first proton beam was injected into the RFQ with more than 90 % of transmission, followed by the first D+ beam accelerated at 5 MeV. The SRF linac necessary for the 9-MeV D+ beam is in the completion phase of components manufacturing and will be assembled in Rokkasho. Based on these results, a conceptual design of the Advanced Fusion Neutron Source (A-FNS) for its construction in Rokkasho is underway to obtain material irradiation data for a DEMO reactor. The A-FNS is designed to be composed of an accelerator facility with a 40 MeV/125 mA D+ beam, a test facility including a liquid Li target system and a post irradiation examination facility, and to enable multipurpose utilization for neutron application.

## Introduction

- The IFMIF (International Fusion Materials Irradiation Facility) / EVEDA (Engineering Validation & Engineering Design Activities) project aiming at material tests for a future fusion DEMO reactor is underway in the international collaboration between EU and Japan (the Broader Approach (BA) Agreement of fusion program). (9 MeV/125 mA/D-beam/CW operation.)
- At QST Rokkasho the construction and commissioning of the Linear IFMIF Prototype Accelerator (LIPAc) to validate the design of IFMIF accelerator up to the first section of SRF linac (9 MeV, 125 mA CW) is ongoing.
- Introduction First H+ beam acceleration by RF Quadrupole Linac (RFQ) has been achieved in June 2018.
- Initial RFQ beam transmission data has been taken a good sign of RFQ design validity (@ H+, 50 keV, 35 mA, duty 0.3 ms / 1 Hz).
- D+ beam commissioning up to RFQ (5 MeV, 125 mA) has been started in 2019.
- A conceptual design of the A-FNS in Rokkasho is underway to obtain material irradiation data for a DEMO reactor on the basis of the results of the IFMIF/EVEDA project.

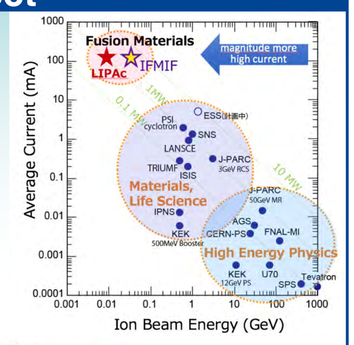
**Neutron Irradiation Facility is necessary for DEMO**

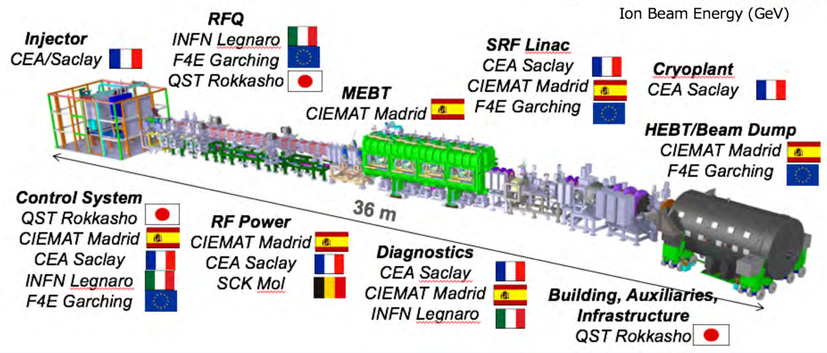


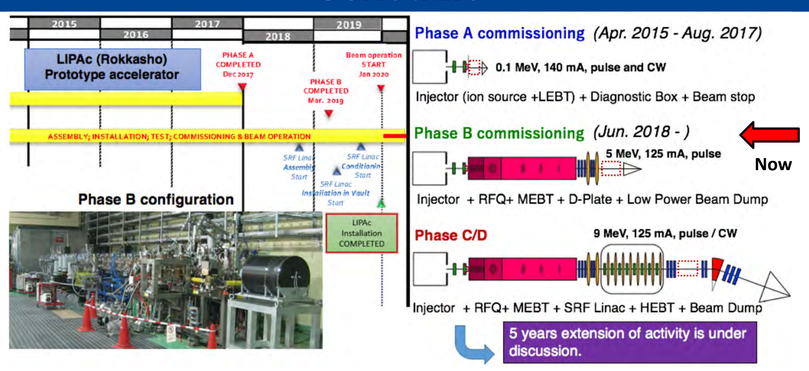

## LIPAc Project

- Mission of LIPAc is to demonstration of feasibility of intense D+ beam acceleration of 125 mA, 9MeV.
- Under the control of implementing agencies of EU (F4E) and Japan(QST) in BA activity, key components are mainly procured by EU research institutions, and the assembly and installation are mainly done by JA (QST) at Rokkasho.
- Test and operation are done to pursue the mission by the EU-JA Joint team.



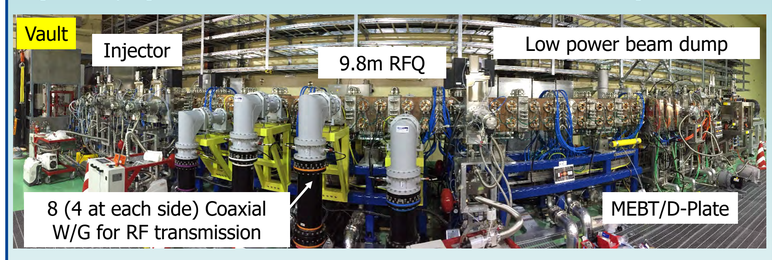



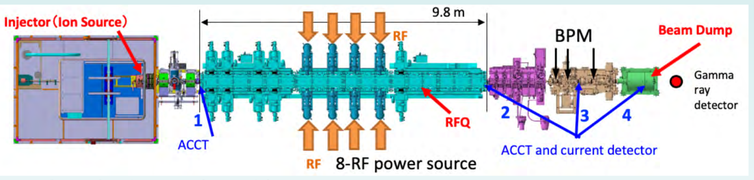

## Schedule



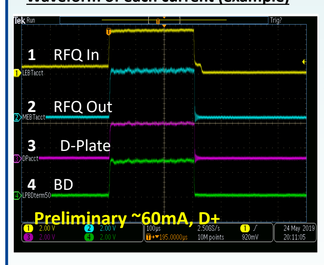

## Recent Progress of LIPAc

Significant progress was achieved on the installation and commissioning of LIPAc.




**Waveform of each current (example)**

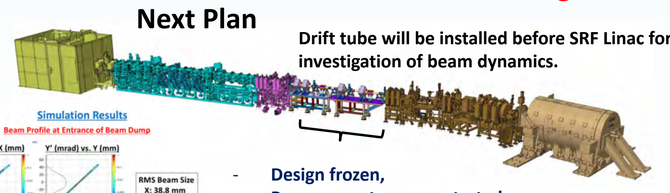



*RFQ beam transmission is very well (> 95% at 55 mA) without steering
*RFQ is tested with proton up to 58 mA current at the RFQ exit, 4ms pulse length (30 mA) and transmission is > 90%.

→Very promising to achieve the final goal
1) High current operation with proton, targeting 62.5 mA at the RFQ exit,.
2) 1st trial of deuteron beam injection was succeeded on 11 Mar.
3) At the moment, deuteron experiment is scheduled in May-Aug.
4) Now under commissioning, current ~ 100mA in June.
5) Target is 125 mA at the RFQ exit with short pulse (> 300 ms).

**Under commissioning**

**Next Plan**

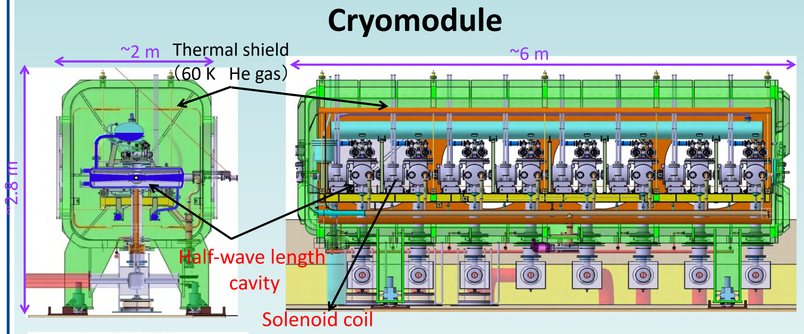


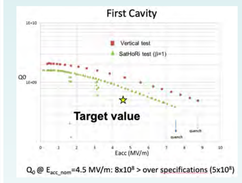

- Design frozen,
- Procurement process started,
- Further beam dynamics assessment ongoing to be finalized before Summer.

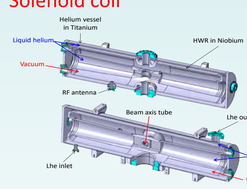
Drift tube will be installed before SRF Linac for investigation of beam dynamics.

## SRF Preparation

**Cryomodule**



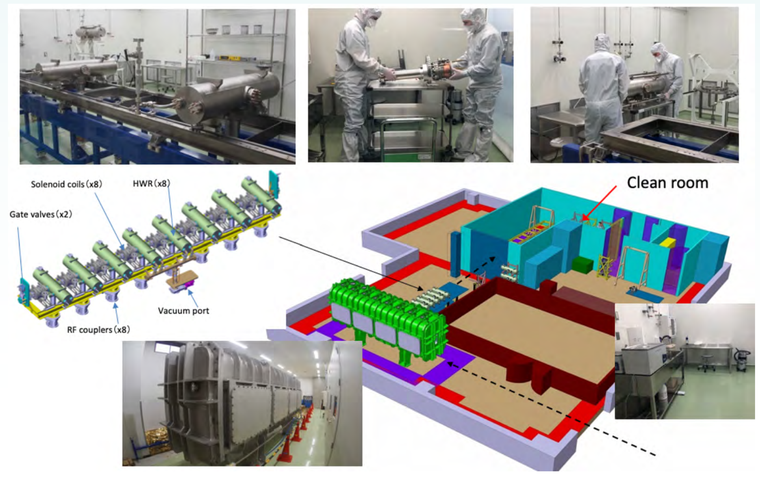




Assembling with 8 cavities and solenoid coils is planned using a clean room (ISO Class 5) at Rokkasho site on 2019.

**Almost all components on site (Rokkasho)**

**SRF Linac assembly in Clean room: Start of assembly operation**




## A-FNS Project in Rokkasho, Japan

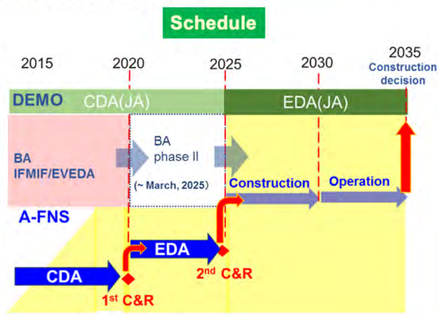
"Japan's road map and action plan to promote R&D for a fusion DEMO reactor" decided in 2017 requires that the material irradiation data should be acquired for a decision in the 2030s to start construction of a DEMO reactor.

**Main objectives of A-FNS**

1. Evaluation on material property of fusion material for neutron irradiation around 2035
2. Study on tritium production and release properties of fusion blanket
3. Evaluation on irradiation effect of diagnostic and controlled devices for DEMO reactor

**Multipurpose usage for industrial radioisotopes production and neutron beam application**

**Schedule**



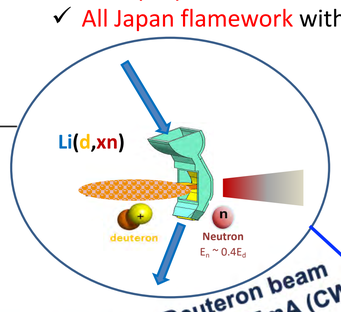

A-FNS consists of
Accelerator Facility with **only one beam line** of 40 MeV and 125 mA D+ and Target and Test Facility.

**A-FNS basic parameter**

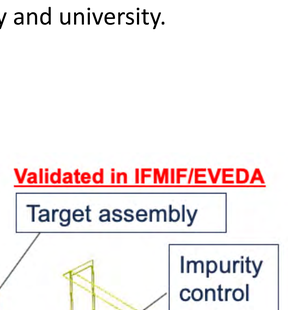
| Items | Basic parameters | Values |
|---|---|---|
| Ion beam | Particle | Deuteron |
| | Incident energy | 40 MeV |
| | Current | 125 mA |
| | Foot print | 200 x 50 mm² |
| Target | Material | Lithium (liquid) |
| | Temperature | 250 ºC |
| | Thickness | 25 ± 1mm |
| | Flow velocity | 15 ms⁻¹ |
| Neutron | Intensity | 6.8 x10¹⁶ s⁻¹ |
| | Flux | 6.0 x10¹⁴ cm⁻² s⁻¹ |
| | He production rate | 312 appm/fpy |
| | Displacement | 24.7 dpa/fpy |

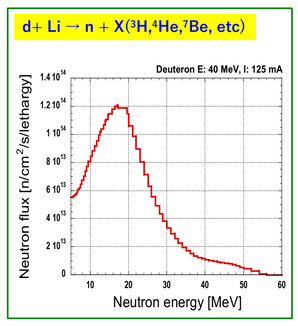
fpy: full power year

- ✓ One line of IFMIF Accelerator (125mA). Design will be based on IFMIF Engineering Report.
- ✓ Li Target loop is almost same of IFMIF/EVEDA. R&D. Purification validation will be done in BA Phase II.
- ✓ Many Irradiation modules will be proposed for Fusion Material Tests. This concept is Japanese origina ideal.
- ✓ Remote handling maintenance using side pull-out with all shielding plugs (Japanese Idea).
- ✓ Multi purpose Neutron Source for Industrial use.
- ✓ All Japan flamework with industry and university.



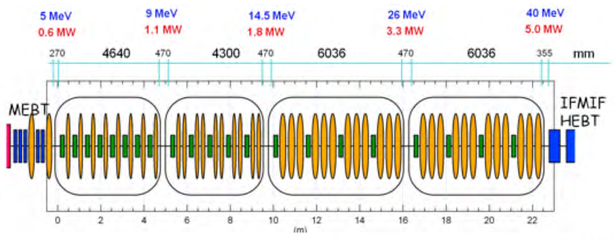

**Validated in IFMIF/EVEDA**



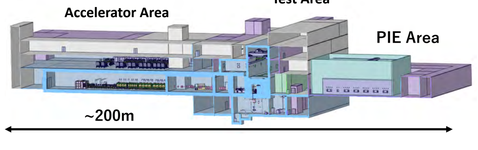




The fundamental analysis of neutron flux was implemented in the test cell as a first priority to design test modules which meet demands and criteria for test materials.

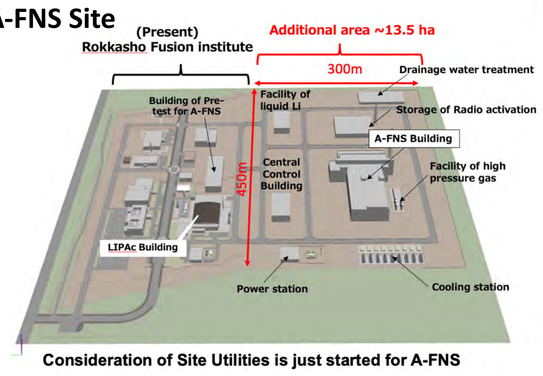
**Cryomodules for A-FNS**



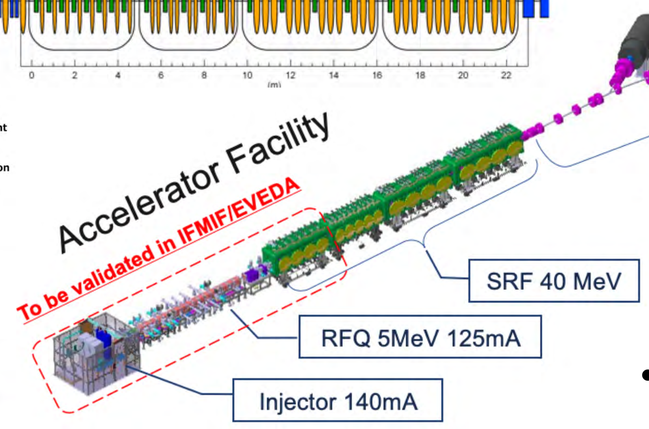

**A-FNS Building**




**A-FNS Site**

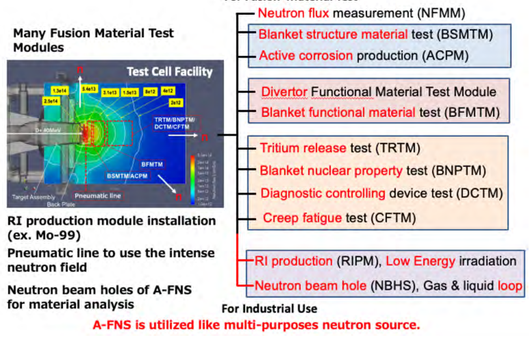



Consideration of Site Utilities is just started for A-FNS




**Target and Test Facility**

- A-FNS will provide not only fusion but also high-energy neutron irradiation field with high general-purpose properties covering domestic basic research, industrial, medical and energy applications.




## Summary

- Deuteron acceleration by the RFQ linac has been just started with pulsed mode.
- Assembly of SRF linac is started in 2019 and to be installed in the accelerator vault in early 2020.
- BA phase II which is five years extension of BA activities is under discussion, for the full demonstration of 125 mA, 9 MeV CW operation in many days, and for resolving the R&D issues common to EU and JA.
- In the second intermediate C&R around 2025, it will be decided whether to make the transition to the construction of A-FNS according to "a Roadmap toward Fusion DEMO Reactor" for which the the Science and Technology Committee on Fusion Energy formulated "Japan's Policy to promote fusion R&D for a fusion DEMO reactor"

[ Reference on SRF2019]

TUP105: T. Ebisawa,
Preparation of the cryomodule assembly for the Liner Ifmif Prototype Accelerator (LIPAc) in Rokkasho

WETEA3: N. Bazin,
Status of the IFMIF/EVEDA Superconducting Linac

This work was undertaken under the Broader Approach Agreement between the European Atomic Energy Community and the Government of Japan. The views and opinions expressed herein do not necessarily state or reflect those of the Parties to this Agreement.